

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference JKH/BA/P10508	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 00682	International filing date (day/month/year) 25/02/2000	(Earliest) Priority Date (day/month/year) 25/02/1999
Applicant MICROSULIS PLC et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☒ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

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☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/00682

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 30-43
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No

PC 00/00682

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61B18/18 A61B17/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 20768 A (EP TECHNOLOGIES, INC.) 28 October 1993 (1993-10-28) page 13, line 4 - line 25; figures 13,14	1,5,13, 23,24
A	US 4 643 186 A (ROSEN ET AL.) 17 February 1987 (1987-02-17) column 3, line 6 - line 40 column 6, line 38 - line 45 figures 1,7A	1,23
A	US 5 129 396 A (ROSEN ET AL.) 14 July 1992 (1992-07-14) column 3, line 56 - line 58; figure 1C	1,23
A	US 4 409 993 A (FURIHATA) 18 October 1983 (1983-10-18) column 3, line 20 - line 50; figure 2	1,23



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

16 May 2000

Date of mailing of the international search report

24/05/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Ducreau, F

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/JP 00/00682

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9320768	A	28-10-1993	US 5370678 A US 5871525 A US 5728144 A	06-12-1994 16-02-1999 17-03-1998
US 4643186	A	17-02-1987	NONE	
US 5129396	A	14-07-1992	US 5150717 A	29-09-1992
US 4409993	A	18-10-1983	JP 1427764 C JP 57025863 A JP 62033906 B AT 8579 T DE 3165055 D EP 0044538 A	25-02-1988 10-02-1982 23-07-1987 15-08-1984 30-08-1984 27-01-1982

14
REC'D 23 MAY 2001

WIPO PCT

Applicant's or agent's file reference JKH/BA/P100508	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/00682	International filing date (day/month/year) 25/02/2000	Priority date (day/month/year) 25/02/1999
International Patent Classification (IPC) or national classification and IPC A61B18/18		
Applicant MICROSULIS PLC et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 8 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 25/09/2000	Date of completion of this report 21.05.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Abraham, V Telephone No. +49 89 2399 7463



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00682

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-8 as originally filed

Claims, No.:

1-43 as originally filed

Drawings, sheets:

1/2,2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/00682

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 30-43.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for the said claims Nos. 30-43.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Yes: Claims 4,6-12,14,15,18,20-22,26,27,29

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International application No. PCT/GB00/00682

	No:	Claims	1-3,5,13,16,17,19,23-25,28
Inventive step (IS)	Yes:	Claims	
	No:	Claims	4,6-12,14,15,18,20-22,26,27,29
Industrial applicability (IA)	Yes:	Claims	1-29
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/00682

Reference is made to the following documents:

D1: US-A-5 693 082 (WARNER ET AL.) 2 December 1997

D2: WO 93 20768 A (EP TECHNOLOGIES, INC.) 28 October 1993

D3: Microwave Catheter Design; NEVELS ET AL.; IEEE Transactions on Biomedical Engineering; Vol. 45; No. 7; July 1998

V

1. The application does not meet the requirement of Article 33(2) PCT, because the subject-matter of claims 1-3, 5, 13, 16, 17 and 19 (as far as being understood, see paragraph VIII below) is not new.

1.1 It is generally known in the field of catheter based microwave devices to provide a dielectric body which surrounds the antenna in order to encompass substantially the whole of the near field of the radiation (see for example D1: column 9, lines 16-35; Fig. 7; D2: page 13, lines 5-12; Fig. 13,14). The subject-matter of claim 1 therefore lacks novelty with regard to documents D1 and D2.

Comment: The radiation pattern around an antenna divides into two portions, the near field and the far field, wherein the near field is "adjacent" the antenna.

Documents D1 and D2 disclose dielectric bodies which surround the antenna and encompass an area "adjacent" the antenna. Accordingly, claim 1 lacks novelty over these documents.

1.2 Since according to general rules in electrodynamics the extension of the near-field as well as the length of the antenna is dependent on the wavelength of the radiation the additional features of claims 2 and 3 are implicitly included in D1 and D2. The subject-matter of claims 2 and 3 therefore lacks novelty.

1.3 The dielectric body comprises a substantially cylindrical portion with the antenna extending axially at its center a distance L (D1: Fig. 7; D2: Fig. 13,14).

1.4 The tip portion extends beyond the end of the antenna (D1: Fig. 7; D2: Fig. 13,14).

1.5 The tip portion is an extension of the dielectric body and is rounded (D1: Fig. 7;

D2: Fig. 13,14).

- 1.6 The tip portion is substantially hemispherical (D1: Fig. 7; D2: Fig. 13,14).
- 1.7 The device comprises a coaxial conductor with a central conductor that projects beyond outer screening of the coaxial conductor at the distal end to form the antenna (This is a conventional whip microwave antenna as described for example in D2: Fig. 14).
2. Dependent claims 4, 6-12,14,15,18,20-22 do not contain any additional features which in combination with the features to which they refer, involve an inventive step (Article 33(3) PCT), since these additional features are known from the prior art as indicated hereinafter and would be readily incorporated by one skilled in the art according to circumstances and in view of their known technical effect.
 - 2.1 As already indicated it is generally known to provide a dielectric body in order to encompass substantially the whole of the near field of the radiation. The definition given in claims 4 and 6 therefore are straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.
 - 2.2 The additional features of claims 7-12 are generally known in the field of medical microwave applicators in order to match the device to the living tissue (see D3: page 888, left column, lines 5-23).
 - 2.3 The skilled person would regard it as a normal design option to include the additional features of claims 14 and 15 in the device described in documents D1 or D2 in order to solve the problem posed, namely to facilitate penetration of biological matter.
 - 2.4 The radius of the hemispherical portion as defined in claim 18 is merely one of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed, namely to enhance transmission in the forward direction. In D1 the hemispherical shape of the dielectric body (see Fig.7) in

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/00682

combination with a straight antenna tip solve the identical technical problem (column 9, lines 13-15).

- 2.5 To provide an antenna having the length of half the wavelength of the radiation as defined in claim 20 is conventional antenna design.
- 2.6 The additional features of claims 21 and 22 are generally known in the field of antenna design (see for example D1: 78).
3. The application does not meet the requirement of Article 33(2) PCT, because the subject-matter of claim 23 (as far as being understood, see paragraph VIII below) is not new.
 - 3.1 Both documents D1 and D2 disclose all features of claim 23: An elongate device having an antenna at its tip and a dielectric body surrounding the antenna (D1: Fig. 7; D2: Fig. 14).
4. The additional features of claims 24-29 have already been dealt with in paragraphs V 2 and V 3 above. Therefore, these claims are not new (claims 24,25,28) or not inventive (claims 26,27 and 29).

VII

1. The independent claims should have been drafted in the two part form in accordance with Rule 6.3(b) PCT, with those features known in combination from D1 or D2 being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in a characterising part (Rule 6.3(b)(ii) PCT).
2. The features of the claims should have been provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
3. According to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D3 should have been mentioned in the description and these documents should have been identified therein.

VIII

1. Claims 1 and 23 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The claims attempt to define the subject-matter in terms of the result to be achieved which merely amounts to a statement of the underlying problem (claim 1: "a dielectric body surrounding the antenna **so as to encompass substantially the whole of the near-field of the radiation** emitted by the antenna"; claim 23: "a dielectric body surrounding the antenna **so as to enhance transmission of radiation in the forward direction**"). The technical features necessary for achieving this result should have been added.

For this report these formulations are not considered as limiting the subject-matter of the claims. Accordingly, they have been disregarded in the assessment given under point V with regard to novelty, inventive step and industrial applicability.

- 1.1 A unity objection may be raised after a clarification of the claims.

The feature common to claims 1 and 23 is the dielectric body surrounding the antenna. As indicated in paragraph V below this feature is not new.

Thus, the common feature is not a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Thus, the independent claims would not specify special technical features in the meaning of PCT Rule 13.2, which are common to all independent claims so that no technical relationship within the meaning of PCT Rule 13.1 between the different subjects exists.

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
 United States Patent and Trademark
 Office
 Box PCT
 Washington, D.C. 20231
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 19 October 2000 (19.10.00)	
International application No. PCT/GB00/00682	Applicant's or agent's file reference JKH/BA/P10508
International filing date (day/month/year) 25 February 2000 (25.02.00)	Priority date (day/month/year) 25 February 1999 (25.02.99)
Applicant NIGEL, Cronin	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

25 September 2000 (25.09.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland

Authorized officer

S. Mafla

Facsimile No.: (41-22) 740.14.35

Telephone No.: (41-22) 338.83.38



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

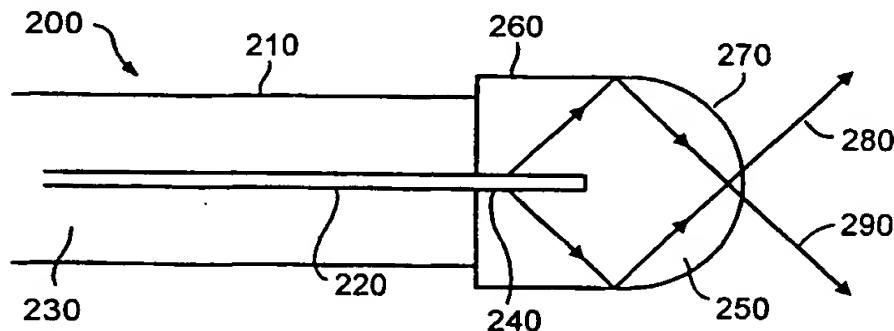
(51) International Patent Classification ⁷ : A61B 18/18, 17/22	A1	(11) International Publication Number: WO 00/49957 (43) International Publication Date: 31 August 2000 (31.08.00)
<p>(21) International Application Number: PCT/GB00/00682</p> <p>(22) International Filing Date: 25 February 2000 (25.02.00)</p> <p>(30) Priority Data: 9904373.9 25 February 1999 (25.02.99) GB</p> <p>(71) Applicant (for all designated States except US): MICROSULIS PLC [GB/GB]; 10 St. Ann Street, Salisbury, Wiltshire SP1 2DN (GB).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): NIGEL, Cronin [GB/GB]; 14 Englishcombe Lane, Bath BA2 2ED (GB).</p> <p>(74) Agent: HOGG, Jeffery, Keith; Withers & Rogers, Goldings House, 2 Hays Lane, London SE1 2HW (GB).</p>		<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report.</p>

(54) Title: RADIATION APPLICATOR

(57) Abstract

Radiation applicators comprise an elongate device having an antenna (240, 340) at their tip for coupling radiation into biological tissue and a dielectric body (250, 350) surrounding the antenna so as to encompass substantially the whole of the near-field region of the antenna and/or to enhance transmission of radiation in the forward direction. The body (250, 350) may be cylindrical with the antenna

(240, 340) along its axis. The antenna may be $\lambda/2$ in length and $\lambda/2$ in radius. The tip (270) of the antenna (240) may be rounded hemispherical with radius $\lambda/2$ to enhance forward transmission of radiation. The dielectric constant (ϵ) of the body (250, 350) is as high as possible to reduce its diameter at a desired operating frequency but may be matched to the surrounding tissue by another layer of dielectric material (380) with a value (ϵ) intermediate that of the core (360) of the body (350) and the tissue.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
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EE	Estonia	LR	Liberia	SG	Singapore		

RADIATION APPLICATOR

This invention relates to radiation applicators and, in particular, to microwave ablation devices.

A known radiation applicator, used for microwave ablation of tissue, comprises a microwave generator operatively coupled to an elongate waveguide for conveying the microwaves to the ablation site. The waveguide is sufficiently thin to be inserted into the body and contains a core of dielectric material which enables efficient transmission of microwaves through the waveguide. At the emission end of the waveguide, the dielectric core protrudes and provides a radiating tip for coupling microwaves into surrounding tissue. An object of the inventor is to provide an improved radiation applicator.

According to one aspect, the invention consists in an elongate device for insertion into a living body, the device having an antenna at its tip for coupling radiation into biological matter and a dielectric body surrounding the antenna so as to encompass substantially the whole of the near-field of the radiation emitted by the antenna.

The invention is based on an appreciation of the fact that the antenna generates a near-field, and that the near-field contains large field amplitudes which exist quasi-statically in the local region of the antenna and do not radiate energy. In a normal communications antenna, this local region is air-filled and these near-field amplitudes have no effect except to contribute reactance to the antenna impedance. However, in a medical application, if the near-field region contains biological matter, which is highly lossy, the near-field amplitudes will generate heat. Because of the high amplitudes and small volume of the near-field region, much heat can be generated in the near-field region, which reduces the energy in the far-field. Field penetration is therefore reduced, and local charring in the near-field region becomes a limiting factor in the power that can be input to the antenna.

The dielectric body according to the invention serves to provide a low loss environment to encompass the near-field region so that more power is transmitted to the biological matter in the far-field region.

The extent of the near-field is determined by the wavelength λ of the radiation in the dielectric and the major dimension L of the antenna according to the relationship $2L^2/\lambda$. Furthermore, in an antenna, L is proportional to λ . The extent of the near-field therefore is proportional to λ , and it is possible to reduce the extent of the near-field region by increasing the dielectric constant of the body to reduce the wavelength of the radiation within it. The overall external dimension of the device can therefore be reduced for insertion into a living body. A higher dielectric constant will also accommodate the use of lower frequency radiation, which would otherwise increase the wavelength and the extent of the near-field; the lower frequency radiation being beneficial in increasing radiation penetration into the far-field.

In one embodiment of the invention, the dielectric body comprises a cylindrical shape with the antenna extending axially along its centre a distance L , with the radius of the cylinder being substantially equal to $2L^2/\lambda$. A device of this kind can be designed with a minimum radius for insertion into biological matter such as a liver, and will create an annular radiation field around it. A pointed tip may be provided at the free end of the dielectric body to assist penetration of biological matter.

The length L of the antenna may be substantially equal to half a wavelength, in which case the radius of the cylindrical dielectric body is substantially equal to half a wavelength. The antenna is then tuned to act as a resonator, which increases the power it radiates.

However, as the dielectric constant is increased, it may exceed that of the biological matter, which can lead to total internal reflection of radiation within the dielectric and a consequent reduction in transmitted radiation. In order to overcome this problem, the dielectric body is formed so that the dielectric constant at its core is higher than that at its outer periphery, the latter having a value intermediate that of the core and the biological matter. Thus, the dielectric constant at the core may be higher than that of the surrounding biological matter so as to help reduce the overall diameter of the device. The different dielectric constants may correspond to different layers of dielectric, each with a different dielectric constant, or may correspond to different levels in a dielectric in which the dielectric constant varies throughout its depth.

According to another aspect, the invention consists in an elongate device for insertion into a living body, the device having an antenna at its tip for coupling radiation into biological matter and a dielectric body surrounding the antenna so as to enhance transmission of radiation in the forward direction of insertion.

Preferably, the dielectric body completely envelops the antenna and has a tip portion that extends beyond the end of the antenna to support internal reflection of the radiation in the forward direction. Advantageously, the dielectric body is tuned to act as a resonator to further enhance radiation from the tip of the elongate device in the insertion direction. In particular, the diameter of the dielectric body is substantially equal to the wavelength of the radiation, and the tip portion is substantially hemispherical and has a radius substantially equal to half a wavelength of the radiation.

The elongate device may further comprise a coaxial conductor (preferably packed with a dielectric) which supplies radiation to the antenna from a radiation generator. Preferably, the antenna then comprises an exposed length of the central conductor of the coaxial conductor at its distal end. Preferably, the exposed length of the central conductor providing the antenna, is substantially half a wavelength long. The coaxial conductor may be rigid or a flexible cable.

Preferably, the dielectric body has a dielectric constant, or relative permittivity, such that the length of the antenna is reduced. Advantageously, there can be a transformer between the coaxial conductor and the dielectric body to reduce reflection of radiation back into the coaxial conductor from the boundary between it and the dielectric body. Such a transformer can advantageously contain a space into which the dielectric packing of the coaxial conductor can expand.

According to yet another aspect, the invention consists in methods of coupling radiation into biological material using the devices according to the invention.

Further advantages and features of the invention will become apparent to readers skilled in the art upon consideration of the following description of embodiments of the invention, the embodiments being described by way of example only, and with reference to the accompanying figures, in which:

Figure 1 shows a first embodiment of the radiation applicator;

Figure 2 shows the tip section of the radiation applicator of Figure 1 in more detail;

Figure 3 shows a second embodiment of the tip section of the radiation applicator incorporating a transformer;

Figure 4 shows a third embodiment of the radiation applicator;

Figure 5 shows the tip of the radiation applicator of Figure 4; and

Figure 6 shows a side-elevation of a variation in design of the radiation applicator of Figure 4.

Figure 1 shows the general arrangement of the radiation applicator system 100. A radiation generator 110, for example, a microwave generator, produces radiation which is coupled into coaxial cable 120 which transmits the radiation to a distal tip region 130 at which there is an antenna for emitting the radiation into the material surrounding the tip 130. In use, the coaxial cable 120 is introduced into a living body and the tip 130 is positioned adjacent a region which it is desired to irradiate. For example, the device could be inserted into an artery to irradiate plaques on the walls thereof or the device could be introduced into a uterus to irradiate the endometrium. The supply of radiation is controlled by a control device 140, often a foot pedal, which is used to signal the microwave generator to begin, adjust or stop the supply of radiation to the tip 130.

Figure 2 shows the tip region 130 of the radiation applicator of figure 1 in more detail. The tip region, generally indicated 200, shows the distal end of the coaxial cable which comprises an outer conductor 210 spaced from a core conductor 220. The space between the conductors 210 and 220 is filled with a dielectric material 230. The antenna for emitting radiation conducted by the cable comprises a length 240 of the core conductor of the coaxial cable extending beyond the outer conductor 210 at the distal end of the coaxial cable. To enhance the radiating qualities of the antenna 240, it is preferred that the length of core conductor providing the antenna is about one half of a wavelength of the radiation in the dielectric. The antenna 240 is enveloped by dielectric body 250 in which the wavelength of the employed radiation is reduced below its free-space value hence enabling

the exposed length 240 of the core conductor providing the antenna to be shorter than might otherwise be possible. In order to enhance radiation from the antenna in the forward direction, the dielectric body 250, in addition to comprising a cylindrical portion 260 which envelops the exposed length of core conductor 240, comprises a hemispherical section 270 which supports partial internal reflection of the radiation from the antenna in the forward direction as indicated by arrows 280 and 290. Preferably, the hemispherical section 270 is dimensioned so as to provide a resonator which further enhances radiation from the dielectric body in 250 in the forward direction. Resonance of radiation partially reflected within the dielectric body 250 can be encouraged by, for example, dimensioning the hemispherical section 270 to have a radius approximately equal to one half of a wavelength of the radiation employed. It will be appreciated that the dielectric body can have other dimensions and shapes provided that they encourage forward propagation of the radiation by means of internal reflection and/or resonance.

When this equipment is to be used for endometrial ablation it is desirable to use radiation having a frequency around 9.2GHz. In free-space, the wavelength of such radiation is about 32mm. Forming the dielectric body from, for example, a material having a dielectric constant $\epsilon_R=25$ reduces the wavelength to about 6mm. Correspondingly, the diameter and overall length of the dielectric body are then also about 6mm.

Figure 3 shows an alternative embodiment of the tip section of the radiation applicator device, generally indicated 300. Here, in order to reduce reflection of radiation from the coaxial cable at the boundary between it and the dielectric body, a transformer 310 is incorporated between the coaxial cable and the dielectric body. The transformer 310 comprises several sections (for example, three: 320, 330, 340) of cylindrical shape and of successively increasing radius towards the dielectric body. Advantageously, at least the section 320 of the transformer adjacent the coaxial cable does not contain a solid filler material. This provides the benefit that, when the device is heated, for example in manufacture or in use, the dielectric material filling the space between the core and outer conductors of the coaxial cable can expand into the transformer thus relieving otherwise deleterious pressures.

The near-field radiation generated by the applicator of Figures 2 and 3 extends from the antenna 240 a distance determined by the formula $2L^2/\lambda$, where L is the exposed length of the antenna, and λ is the wavelength of the radiation in the dielectric body 250. However, the preferred value of L is $\lambda/2$, and therefore the near-field radiation is contained within a region of radius $\lambda/2$ about the antenna. Therefore, the near-field radiation does not extend into the more lossy biological material that surrounds the applicators in use, and the resulting detrimental affects of local charring and reduction of radiation penetration are reduced or avoided. Instead, the microwave power is emitted into the far-field to increase penetration and power transfer.

Figure 4 shows yet another embodiment of the invention in which a generator 310 supplies microwave energy via a rigid coaxial conductor 320 to a tip region at the distal end of the conductor. Dielectric packing 330 is provided between the inner and outer conductors of the coaxial conductor 320. As shown in more detail in Figure 5, a length of the inner conductor 340 at the tip is exposed by removal of the outer conductor so as to form an antenna to emit radiation. The antenna 340 is embedded axially in a cylindrical body of dielectric 350 which has substantially the same outer diameter as the coaxial conductor 320. A pointed metal tip 370 is fixed to the end of the dielectric body 350 and serves to assist penetration into biological matter, such as a liver to perform ablation on a tumour. The antenna 340 preferably has a length substantially equal to half a wavelength of the radiation in the dielectric, and the radius of the dielectric body 350 is also preferably substantially equal to half a wavelength of the radiation in the dielectric. The near-field radiation emitted by the antenna will then lie within a region $2L^2/\lambda$, which is equal to a radius of half of the wavelength of the radiation in the dielectric so that the near-field lies substantially totally within the dielectric. The dielectric constant of the dielectric body is selected to be high so as reduce losses within the dielectric. The microwave energy is therefore emitted into the far-field region in an annular pattern around the tip so as to increase field penetration and power transfer. Typically, a radiation applicator used with a generator operating at 10 GHz and having a dielectric body with dielectric constant $\epsilon_R=25$, will have a dielectric body radius of 3 mm.

In order to reduce the diameter of the tip of the applicator, the dielectric body is made of a material with as high a dielectric constant as possible, except that this is limited by the dielectric constant of surrounding biological matter in which the applicator is used. When the dielectric constant of the dielectric body exceeds that of the biological matter, total internal reflection can occur at the outer surface of the dielectric body, and field penetration becomes evanescent and localised. In order to overcome this limitation, the dielectric body 350 may be formed with an inner core 360 composed of a material with a high dielectric constant, and an outer layer 380 composed of a dielectric with a lower dielectric constant intermediate that of the core and the surrounding biological material so as to match the wave impedance of the radiation between the core and the biological material. In order to achieve this, the refractive index of the outer layer 380 should be equal to the geometric mean of the refractive index of the core 360 and that of biological material, and the outer layer thickness should be equal to a quarter of the wavelength of the radiation in the outer layer. Thus, the core radius would also be equal to a quarter of the wavelength of the radiation in the core in order to produce an overall nominal radius of half a wavelength at the tip.

In alternative embodiments of the invention, multiple outer layers may be used to increase the band-width of the applicator (i.e. the range of frequencies over which the applicator can be used) by making the layers each with a suitable refractive index and thickness. However, this will lead to an increase in the overall diameter of the tip. In the limit, the dielectric body could be made with a continuously varying refractive index which decreases towards its outer surface.

An alternative technique to reduce the dielectric constant of the outer layer 380 comprises forming indentations such as grooves 390, shown in Figure 6, in the outer surface so that the average dielectric constant of the dielectric and the material in the grooves is reduced. The grooves may run longitudinally or circumferentially around the body 350.

It will be appreciated that the embodiment of Figures 2 and 3 can also be modified to incorporate an outer layer or layers of different dielectric constant, such as shown in Figures 5 and 6, the outer layer following the curve of the hemispherical tip.

Dielectric materials with a high dielectric constant that are suitable include those such as TiO_2 with a permittivity of 100 and CaTiO_2 with a permittivity of 155. These dielectrics would be suitable for use in the core 360 so as to reduce its diameter. The outer layer(s) 370 could be made of a composite of TiO_2 and AlO_2 having a permittivity between that of the core and the biological material. Materials with even higher permittivities may be used such as ferroelectric materials, an example being $\text{Ba}_{1-x}\text{Sr}_x\text{TiO}_3$ (BST) which has a permittivity of around 600.

Therefore, by suitable choice of dielectric(s) it is possible to produce radiation applicators with a tip diameter as low as 3 to 6 mm to allow their use in laparoscopic medical procedures, or even below 3 mm to allow percutaneous medical procedures.

Radiation applicators according to the invention can also be used to measure the dielectric constant of biological material by measuring the microwave radiation reflected back from the tip through the coaxial conductor.

Claims

1. An elongate device for insertion into a living body, the device having an antenna (240,340) at its tip for coupling radiation into biological matter and a dielectric body (250,350) surrounding the antenna so as to encompass substantially the whole of the near-field of the radiation emitted by the antenna.
2. A device as claimed in claim 1 in which the dielectric body (250,350) extends from the antenna (240,340) a distance determined in accordance with the wavelength of said radiation in the dielectric.
3. A device as claimed in claim 1 or 2 in which the dielectric body (250,350) extends from the antenna a distance determined in accordance with the major dimension (L) of the antenna (240,340) in the dielectric.
4. A device as claimed in any one of the preceding claims in which the dielectric body (250,350) extends from the antenna (240,340) a distance at least substantially equal to $2L^2/\lambda$, where L is the major dimension of the antenna and λ is the wavelength of the radiation in the dielectric.
5. A device as claimed in any one of the preceding claims in which the dielectric body (250,350) comprises a substantially cylindrical portion with the antenna (240,340) extending axially at its centre a distance L.
6. A device as claimed in any of claims 2 to 5 in which the dielectric body (250,350) extends from the antenna (240,340) a distance substantially equal to half the wavelength of said radiation in the dielectric.

7. A device as claimed in any one of the preceding claims in which the dielectric body (350) is such that it has a dielectric constant at its core (360) which is higher than the dielectric constant at its outer periphery (380), the latter being more closely matched to that of said living tissue.
8. A device as claimed in claim 7 in which the dielectric body (350) comprises an inner core (360) and an outer layer (380), each of a different dielectric constant.
9. A device as claimed in claim 8 in which the inner core (360) and outer layer (380) have those dimensions that extend from the antenna (340) determined in accordance with the dielectric constant of each so that the overall dimension is a predetermined fraction of the nominal wavelength of the radiation in the dielectric.
10. A device as claimed in claim 9 in which the inner core (360) and outer layer (380) each have a dimension substantially equal to a quarter of the wavelength of radiation therein.
11. A device as claimed in any of claims 8 to 10 in which the outer layer (380) is formed with indentations in its outer surface which serve to reduce the dielectric constant in this region when the indentations are filled with other matter.
12. A device as claimed in claim 7 in which the dielectric constant of the dielectric body (350) varies continuously over at least a part of the distance from the antenna (340).
13. A device as claimed in any one of the preceding claims which has a tip portion (270,370) that extends beyond the end of the antenna.
14. A device as claimed in claim 13 in which the tip portion (370) is pointed to assist penetration of biological matter.
15. A device as claimed in claim 14 in which the tip portion (370) is composed of a different material to the dielectric body (340).

16. A device as claimed in claim 13 in which the tip portion (270) is an extension of the dielectric body (250) and is rounded so as to support forward transmission of radiation.
17. A device as claimed in claim 16 in which the tip portion (270) is substantially hemispherical.
18. A device as claimed in claim 17 in which the tip portion (270) has a radius substantially equal to half the wavelength of the radiation in the dielectric (250).
19. A device as claimed in any one of the preceding claims in which the elongate device comprises a coaxial conductor (120,320) with a central conductor (220,240) that projects beyond outer screening of the coaxial conductor at the distal end to form the antenna (240,340).
20. A device as claimed in claim 19 in which the antenna (240,340) has a length substantially equal to half the wavelength of the radiation in the dielectric.
21. A device as claimed in claims 19 or 20 including a transformer (310) between the coaxial conductor (120,320) and the dielectric body (250,350) to reduce reflection of radiation back into the coaxial conductor at the boundary with the dielectric body.
22. A device as claimed in claim 21 in which the transformer (310) includes a space within the coaxial conductor into which packing of the coaxial conductor can expand.
23. An elongate device for insertion into a living body, the device having antenna (240) at its tip for coupling radiation into biological matter and a dielectric body (340) surrounding the antenna (240) so as to enhance transmission of radiation in the forward direction.

24. A device as claimed in claim 23 in which the dielectric body (250) has a rounded tip portion (270) that extends beyond the end of the antenna (240) to support forward transmission of radiation reflected internally from the outer surface of the dielectric body.
25. A device as claimed in claim 24 in which the tip portion (270) is substantially hemispherical.
26. A device as claimed in claim 25 in which the tip portion (270) has a radius substantially equal to half the wavelength of the radiation in the dielectric.
27. A device as claimed in any one of claims 23 to 26 in which the antenna (240) extends a distance substantially equal to half the wavelength of said radiation in the dielectric.
28. A device as claimed in any one of claims 23 to 27 in which the dielectric body (250) comprises a substantially cylindrical portion with the antenna means (240) extending axially at its centre.
29. A device as claimed in any one of claims 23 to 28 in which the dielectric body (250) extends from the antenna (240) a distance substantially equal to half a wavelength of the radiation in the dielectric body.
30. A method of coupling radiation into biological material, the radiation being generated by an applicator comprising an antenna (240,340) surrounded by a dielectric body (250,350), comprising the steps of selecting the dielectric constant of the body (250,350) in accordance with the wavelength of the radiation in the dielectric so that substantially the whole of the near-field of the radiation is encompassed by the dielectric body (250,350).
31. A method as claimed in claim 30 in which the dielectric constant of the body (250,350) is further selected in accordance with the major dimension of the antenna (240,340).

32. A method as claimed in claim 30 or claim 31 in which the dielectric body (250,350) extends from the antenna a distance at least substantially equal to $2L^2/\lambda$, where L is the major dimension of the antenna and λ is the wavelength of the radiation in the dielectric.
33. A method as claimed in any one of claims 30 to 32 in which the major dimension of the antenna (240,340) is its length, which is substantially equal to half a wavelength of the radiation in the dielectric.
34. A method as claimed in any one of claims 30 to 33 in which the dielectric body (250,350) is located in relation to the biological material so that the far-field radiation lies within the biological material.
35. A method as claimed in any one of claims 30 to 34 in which the dielectric constant of the body (250,350) is high, but is lower than that of the biological material.
36. A method as claimed in any one of claims 30 to 34 in which the dielectric constant of the dielectric body (350) varies, and is higher at its core (360) than its outer periphery (380), and the dielectric constant at its outer periphery is lower than that of the surrounding biological matter.
37. A method as claimed in claim 35 in which the dielectric constant at the core (360) is greater than the dielectric constant of the biological matter.
38. A method of coupling radiation into biological material, the radiation being generated by an elongate applicator comprising an antenna (240) surrounded by a dielectric body (250), the dielectric body being configured so as to enhance transmission of the radiation in the forward direction along the elongate axis of the applicator.
39. A method as claimed in claim 38 in which radiation is partially reflected internally of the dielectric body (250) so as to be transmitted in the forward direction.

40. A method as claimed in claim 39 in which the dielectric constant of the body (250) is high but is lower than that of the biological material.
41. A method as claimed in any one of claims 38 to 40 in which the dielectric body (250) has a substantially hemispherical tip portion (270) with a radius substantially equal to half the wavelength of the radiation in the dielectric.
42. A method as claimed in any one of claims 38 to 41 in which the antenna (240) has a length substantially equal to half the wavelength of the radiation in the dielectric.
43. A method as claimed in any one of claims 38 to 42 in which the dielectric body (250) extends from the antenna (240) a distance substantially equal to half the wavelength of the radiation in the dielectric.

1 / 2

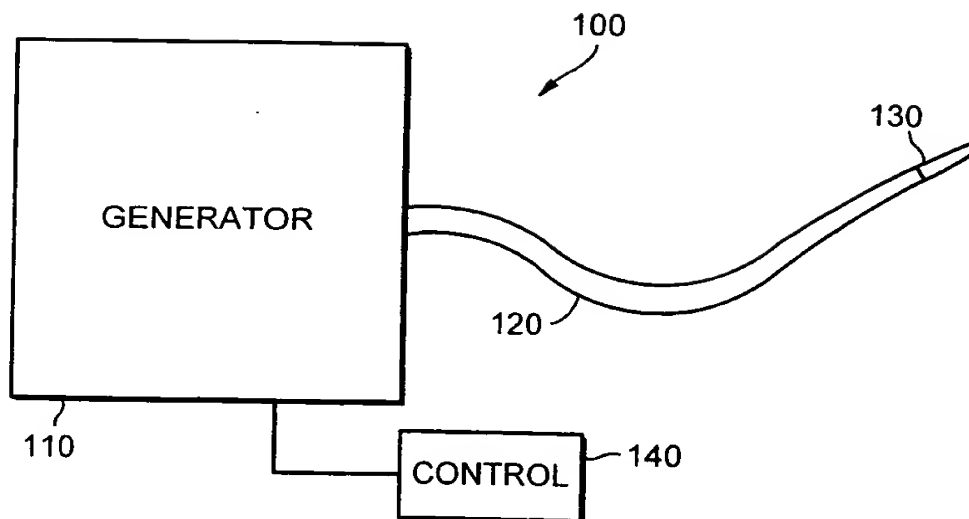


FIG. 1

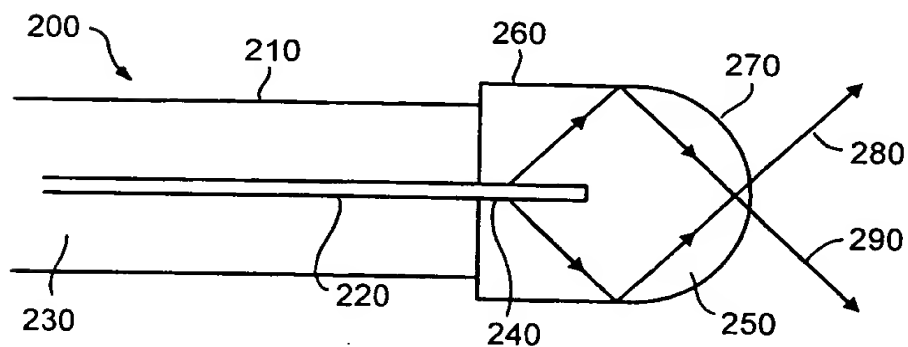


FIG. 2

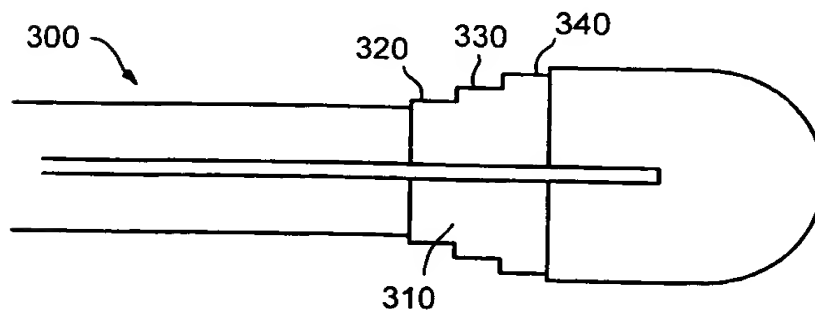


FIG. 3

2 / 2

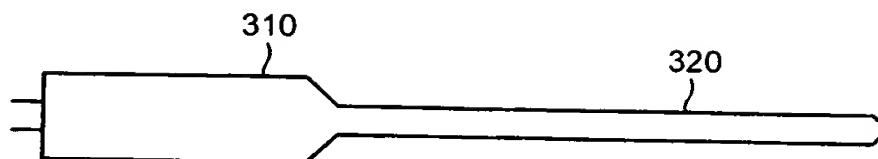


FIG. 4

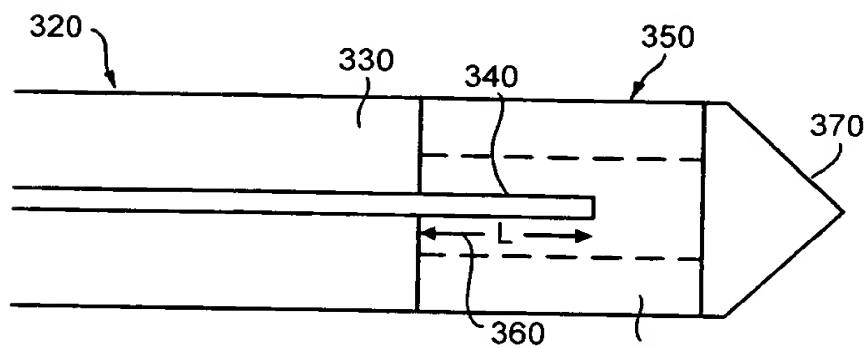


FIG. 5

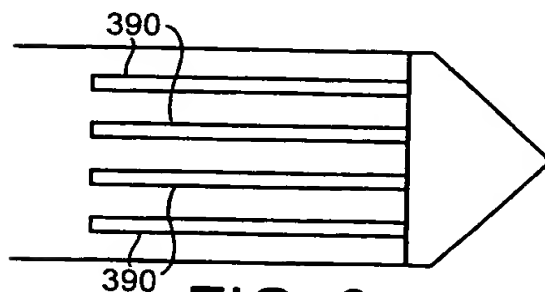


FIG. 6

INTERNATIONAL SEARCH REPORT

Int. Application No.
PCT/GB 00/00682

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B18/18 A61B17/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 20768 A (EP TECHNOLOGIES, INC.) 28 October 1993 (1993-10-28) page 13, line 4 - line 25; figures 13,14	1,5,13, 23,24
A	US 4 643 186 A (ROSEN ET AL.) 17 February 1987 (1987-02-17) column 3, line 6 - line 40 column 6, line 38 - line 45 figures 1,7A	1,23
A	US 5 129 396 A (ROSEN ET AL.) 14 July 1992 (1992-07-14) column 3, line 56 - line 58; figure 1C	1,23
A	US 4 409 993 A (FURIHATA) 18 October 1983 (1983-10-18) column 3, line 20 - line 50; figure 2	1,23

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

*** Special categories of cited documents :**

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "Z" document member of the same patent family

Date of the actual completion of the international search

16 May 2000

Date of mailing of the international search report

24/05/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Ducureau, F

INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB 00/00682

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 30-43
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Application No

PCT/GB 00/00682

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9320768	A	28-10-1993	US 5370678 A	06-12-1994
			US 5871525 A	16-02-1999
			US 5728144 A	17-03-1998
US 4643186	A	17-02-1987	NONE	
US 5129396	A	14-07-1992	US 5150717 A	29-09-1992
US 4409993	A	18-10-1983	JP 1427764 C	25-02-1988
			JP 57025863 A	10-02-1982
			JP 62033906 B	23-07-1987
			AT 8579 T	15-08-1984
			DE 3165055 D	30-08-1984
			EP 0044538 A	27-01-1982